A Time Series Econometric Analysis of Demographic Transition and Gross Domestic Product per Capita: The Effects of Fertility, Employment, Fixed Capital Formation, and Life Expectancy in the Philippines (1991–2024)

Chapter 1 - INTRODUCTION

Main Topic

The study examines the effects of:

- Fertility Rate (FR)
- Employment-to-Population Ratio (EPR)
- Gross Fixed Capital Formation (GFCF)
- Years of Life Expectancy (YLE)

on Gross Domestic Product per Capita (GDPPC) in the Philippines using time-series data from 1991–2024.

Background of the Study

- Population aging affects economic growth.
- Declining fertility reduces labor force growth.
- Higher life expectancy increases dependency burden.
- Countries like Japan and Thailand already experience aging-related economic issues.
- The Philippines is beginning to experience similar demographic transition patterns.

Objectives of the Study

General Objective: Determine the influence of demographic and macroeconomic variables on GDP per capita in the Philippines.

Specific Objectives:

1. Analyze trends of variables from 1991–2024.
2. Determine relationships between variables and GDP per capita.
3. Measure individual and collective effects of variables.
4. Test statistical reliability of the econometric model.
5. Check OLS assumptions and diagnostic tests.

Theoretical Framework

Demographic Transition Theory
Authors:

- Warren Thompson
- Frank Notestein

Main Idea: Countries transition from high fertility and mortality rates to low fertility and longer life expectancy as economies develop.

Implication:

- Early stage → demographic dividend
- Later stage → aging population and economic burden

Neoclassical Growth Theory

Author:

- Robert Solow

Main Idea: Economic growth depends on labor, capital, and technology.

Variables Used:

- Labor → Employment-to-Population Ratio
- Capital → Gross Fixed Capital Formation

Conceptual Framework

Where:

- GDPPC = Gross Domestic Product per Capita
- FR = Fertility Rate
- EPR = Employment-to-Population Ratio
- GFCF = Gross Fixed Capital Formation
- YLE = Years of Life Expectancy

Expected Relationships

- Fertility Rate → Negative relationship with GDPPC
- Employment-to-Population Ratio → Positive relationship with GDPPC
- Gross Fixed Capital Formation → Positive relationship with GDPPC
- Years of Life Expectancy → Positive but insignificant relationship with GDPPC

Research Design

- Research Design: Quantitative
- Method: Time-Series Analysis
- Period: 1991–2024
- Data Source: World Bank
- Software: Stata
- Statistical Tools: Multiple Regression and OLS

Statement of the Problem

1. What are the trends of the variables from 1991–2024?
2. Is there a significant relationship between the variables and GDP per capita?
3. What are the individual and collective effects of the variables?
4. Is the model statistically reliable?
5. Does the model satisfy OLS assumptions?

Hypotheses

Null Hypotheses:

- No significant relationship exists between:
  - FR and GDPPC
  - EPR and GDPPC
  - GFCF and GDPPC
  - YLE and GDPPC
- Independent variables do not significantly affect GDPPC individually or collectively.
- The model is not statistically reliable and violates OLS assumptions.

Scope and Limitations

Scope:

- Philippines only
- 1991–2024 data
- Focus on GDPPC, FR, EPR, GFCF, and YLE

Limitations:

- Small dataset (34 years)
- Uses only secondary data
- Findings may not apply to other countries

Significance of the Study

- Students and Researchers → Reference for econometric studies
- Government → Policy formulation
- General Public → Awareness of demographic effects
- Businesses → Labor and investment planning

Definition of Terms

GDP per Capita - Economic output per person measured in constant 2015 US dollars.

Fertility Rate - Average number of children a woman is expected to have.

Gross Fixed Capital Formation - Investments in fixed assets such as machinery and infrastructure.

Employment-to-Population Ratio - Percentage of the working-age population that is employed.

Years of Life Expectancy - Average number of years a person is expected to live.

Chapter 2 - REVIEW OF RELATED LITERATURE AND STUDIES

This chapter reviews related literature and studies about:

- GDP per capita
- Demographic transition
- Fertility rate
- Employment-to-Population Ratio (EPR)
- Gross Fixed Capital Formation (GFCF)
- Life Expectancy

The chapter explains how these variables affect economic growth and productivity.

GDP per Capita and Demographic Transition

Demographic Transition Theory

Authors:

- Warren Thompson (1929)
- Frank Notestein (1945)

Main Idea:

- Declining fertility and increasing life expectancy change population structure and economic performance.

Related Authors and Findings

- Ahmed and Cruz (2016) - Increase in working-age population raises GDP per capita through higher labor supply and productivity.
- Kotschy and Bloom (2023) - Timing of demographic transition affects long-run GDP per capita growth.
- Lee and Shin (2019) - Effects of demographic transition are nonlinear and stronger in later stages.
- IMF (2017) - Demographic dividend boosts growth, but aging later creates demographic tax.
- United Nations ESCAP (2022) - Rapid aging in Asia-Pacific increases dependency burden and affects productivity.
- Albert et al. (2025) - Southeast Asian countries experience different stages of demographic transition.
- Roslan (2025) - Malaysia's fertility decline affects macroeconomic performance.
- IMF (2024) - Countries in early demographic transition can still benefit from demographic dividend.
- Abrigo et al. (2018) - Philippines currently benefits from youthful population structure.
- Trong, Dong, and Pham (2024) - Higher old-age dependency ratio lowers per capita income.

Relationship

- Demographic transition affects GDP per capita through labor supply, dependency ratio, and productivity.

GDP per Capita and Fertility Rate

Related Authors and Findings

- Thompson (1929) and Notestein (1945) - Lower fertility is part of demographic transition.
- Kearney and Levine (2025) - High-income countries experience declining fertility below replacement level.
- Doepke et al. (2022) - Couples prioritize child quality over quantity as economies develop.
- Huang (2024) - Sustained fertility decline may reduce long-term economic growth.
- Zhang (2023) - Low fertility reduces future labor force size.
- Obi (2019) - East Asian economies benefited from fertility decline through higher productivity.
- Yeo and Nga (2019) - Higher fertility creates dependency pressure and weakens economic growth.
- Pednekar et al. (2023) - Declining fertility may increase female labor participation.
- Wu et al. (2023) - China experienced shrinking workforce due to fertility decline.
- Marques (2025) - Lower fertility significantly increases cumulative economic growth.
- NEDA (2023) - Philippine fertility declined below replacement level.
- Abrigo and Estopace (2023) - Declining fertility in the Philippines is linked to higher living standards.
- Abrigo (2018) - Lower fertility allows greater investment in education and health.

Relationship

- Fertility Rate → Negative relationship with GDP per capita

GDP per Capita and Employment-to-Population Ratio (EPR)

Theoretical Basis

- Neoclassical Growth Theory by Robert Solow (1956) - Labor is a major factor of production.

Related Authors and Findings

- ILO (2022) - Higher employment improves productivity and labor-market outcomes.
- Bloom, Canning, and Fink (2018) - Greater employment coverage increases GDP per capita and productivity.
- IMF (2017) - Weak labor utilization limits income growth.
- OECD (2023) - Aging societies need high employment participation to sustain growth.
- World Bank (2025) - Job creation contributes to rising incomes in the Philippines.
- PIDS (n.d.) - Philippine growth is sometimes considered "jobless growth."
- PIDS (2021) - Underemployment weakens productivity gains.
- PSA (2017) - Underemployment refers to workers wanting additional work hours.
- OECD (2026) - Productivity improvements are needed for long-term income growth.
- World Bank (2023) - Higher EPR increases labor utilization and GDP per capita.

Relationship

- Employment-to-Population Ratio → Positive relationship with GDP per capita

GDP per Capita and Gross Fixed Capital Formation (GFCF)

Theoretical Basis

- Solow (1956) - Capital accumulation increases output per worker.
- Mankiw, Romer, and Weil (1992) - Physical and human capital influence income growth.

Related Authors and Findings

- Yeboah and Adamec (2025) - GFCF has long-run positive effects on economic growth.
- Harnphattananusorn (2022) - Investment sustains GDP growth in OECD countries.
- Morina (2023) - GFCF and GDP have long-run bidirectional relationship.
- Choirunnisa and Yusfi (2025) - GFCF positively affects GDP per capita in ASEAN economies.
- Shaheen et al. (2024) - Investment improves productive efficiency and output.
- Seti, Mazwane, and Christian (2025) - Capital accumulation supports long-run growth.
- Dawood et al. (2024) - Fixed capital formation positively affects economic output.
- Rivera et al. (2024) - Structural bottlenecks limit productivity gains in the Philippines.
- Lumabao et al. (2023) - Investment may not immediately increase GDP growth in short run.
- BSP (2024) - Investment and efficiency improve long-run output per capita.

Relationship

- Gross Fixed Capital Formation → Positive relationship with GDP per capita

GDP per Capita and Life Expectancy

Theoretical Basis

- Thompson (1929) and Notestein (1945) - Longer life expectancy changes age structure and dependency ratios.

Related Authors and Findings

- Lee (2016) - Aging populations increase dependency burden and healthcare costs.
- Überführ (2023) - Life expectancy may have insignificant or negative effects on GDP per capita.
- Cervellati and Sunde (2015) - Effects of longevity depend on demographic transition stage.
- Hansen and Lönstrup (2015) - Longevity positively affects GDP growth in post-transition economies.
- Roffia et al. (2023) - Lower-income countries generally have lower life expectancy.
- World Bank (2022) and WHO (2020) - Better economic conditions improve life expectancy.
- Li and Zhang (2016) - GDP per capita and life expectancy have long-run positive relationship.
- World Bank (2021) - Human capital accounts for 70% of Philippine wealth.
- ADB (2024) - Philippines is not yet considered an aging society.
- Abrigo et al. (2016) - Demographic dividend may improve savings and productivity.

Relationship

- Life Expectancy → Positive but statistically insignificant relationship with GDP per capita

Synthesis of Literature and Studies

Main Findings:

- Demographic transition affects labor supply and productivity.
- Declining fertility can reduce dependency burden and improve human capital.
- Higher employment increases economic output.
- Capital investment improves productive capacity.
- Life expectancy alone does not guarantee higher GDP per capita.
- Philippines still has demographic dividend potential.

Overall Conclusion

GDP per capita is influenced by:

- demographic structure
- labor participation
- investment
- human capital

The Philippines can still maximize demographic dividend through:

- better employment quality
- efficient investment
- stronger human capital development

Chapter 3 – RESEARCH METHODOLOGY

Research Design

Purpose of the Study

The study examines the effects of:

- Fertility Rate (FR)
- Employment-to-Population Ratio (EPR)
- Gross Fixed Capital Formation (GFCF)
- Years of Life Expectancy (YLE)

on Gross Domestic Product per Capita (GDPPC) in the Philippines during demographic transition.

Main Objective

Determine how demographic and macroeconomic variables influence GDP per capita over time in the Philippines.

Research Approach

- Quantitative Research
- Uses numerical and time-series data
- Applies econometric and statistical methods

Purpose:

- objectively analyze relationships between variables
- test hypotheses
- identify trends and effects over time

Research Design Used

Descriptive Research

- examines trends and behavior of variables over time

Explanatory Research

- determines individual and collective effects of independent variables on GDP per capita

Dependent Variable

Gross Domestic Product per Capita (GDPPC)

- indicator of economic performance and living standards
- transformed into natural logarithm form:

lnGDPPC\ln GDPPClnGDPPC

Purpose of Log Transformation:

- reduce skewness
- stabilize variance
- satisfy OLS assumptions
- improve linear relationship
- interpret coefficients in percentage terms

Independent Variables

- Fertility Rate (FR)
- Employment-to-Population Ratio (EPR)
- Gross Fixed Capital Formation (GFCF)
- Years of Life Expectancy (YLE)

Basis for Selection:

- supported by economic theories
- supported by empirical literature

Statistical and Econometric Tools

Multiple Linear Regression

- determines strength and direction of relationships between variables

Ordinary Least Squares (OLS)

- estimates regression coefficients
- tests significance of variables

Importance of the Research Design

The research design helps:

- analyze economic productivity
- identify demographic and macroeconomic patterns
- provide evidence-based policy recommendations
- support Sustainable Development Goal 8 (SDG 8):
  - decent work
  - sustainable economic growth

Sources of Data

Type of Data - Secondary Data & Annual Time-Series Data

Period Covered - 1991–2024, 34 observations

Data Source - World Bank

Variables Used

- GDP per capita
- Fertility Rate
- Employment-to-Population Ratio
- Gross Fixed Capital Formation
- Life Expectancy

Purpose:

- ensure consistency
- ensure reliability of econometric analysis

Statistical Treatment

The data gathered were analyzed and interpreted using the following statistical tools:

I. Multiple Regression

This study will use Stata as the primary statistical software to analyze the relationship between the dependent and independent variables and to examine trends in the confounding variables. The primary statistical technique employed is Ordinary Least Squares (OLS) regression, which estimates the relationship between a dependent variable and one or more independent variables by minimizing the sum of squared error terms. Accordingly, the collected data will be analyzed using OLS to ensure efficient and unbiased parameter estimates. The regression analysis will evaluate the magnitude and direction of the independent variables' effects on the dependent variable.

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots + \mu_t$$

Source: Introductory econometrics: A modern approach (2020, 7th ed., p. 69)

Econometric Model

Variables	Unit of Measurement	Sources
Gross Domestic Product Per Capita	Log Form	**World bank**
Fertility Rate	Percentage	**World bank**
Employment-to-population ratio	Percentage	**World bank**
Gross Fixed Capital Formation	Percentage	**World bank**
Years of life expectancy	Years	**World bank**

$$lnGDPPC_t = \beta_0 + \beta_1 FR_{1t} + \beta_2 GFCF_{2t} + \beta_3 EPR_{3t} + \beta_4 YLE_{4t} + \pi_t$$

$$Whereas:$$

$$lnGDPPC = Natural\ Logarithm\ of\ Gross\ Domestic\ Product\ Per\ Capita$$

$$FR = Fertility\ Rate$$

$$EPR = Employment\ to\ Population\ Ratio$$

$$GFCF = Gross\ Fixed\ Capital\ Formation$$

$$YLE = Years\ of\ Life\ Expectancy$$

$$\mu = standard\ error\ term$$

$$t = 1991\ to\ 2024$$

Correlation

Pearson's product–moment correlation coefficient is employed to measure the degree of linear relationship between two variables. In this study, the data are used to determine whether significant correlations exist between natural logarithm of Gross Domestic Product per capita and Fertility Rate, Gross Fixed Capital Formation, Employment-to-Population Ratio, and Years of Life expectancy.

$$r = \frac{\Sigma(X-\bar{X})(Y-\bar{Y})}{\sqrt{\Sigma(X-\bar{X})^2\ \Sigma(Y-\bar{Y})^2}}$$

Source: Introductory business statistics (2023, 2nd ed., p.537)

$$Where:$$

$$\sum = Number\ of\ pairs\ of\ sources$$

$$\sum xy = Sum\ of\ the\ products\ of\ paired\ scores$$

$$\sum x = Sum\ of\ x\ scores$$

$$\sum y = Sum\ of\ y\ scores$$

$$\sum x^2 = Sum\ of\ squared\ x\ scores$$

$$\sum y^2 = Sum\ of\ squared\ y\ scores$$

Degree of Correlation

Degree of Correlation	Positive Correlation	Negative Correlation
Perfect Correlation	+1	-1
Very High Degree of Correlation	+0.9	-0.9
Relatively High Degree of Correlation	Between +0.75 and +0.9	Between -0.75 and -0.9
Moderate Degree of Correlation	Between +0.25 and +0.75	Between -0.25 and -0.75
Low Degree of Correlation	Between 0 and +0.25	Between 0 and -0.25
Zero/ No Correlation (Uncorrelated)	0	0

Source: nikitajaincalm (2025), https://www.geeksforgeeks.org

The following statistical tests were used to provide data that would answer and further support the hypotheses presented in Chapter 1:

1. Test of Individual Significance of the Regression

A t-test was used to assess whether the regression coefficient is statistically significant. In the case of a t-test that is greater than the critical value (at a significance level of 0.05), we will reject the null hypothesis.

$$t_{\hat{\beta}_j} = \frac{\hat{\beta}_j}{SE(\hat{\beta}_j)}$$

Source: Introductory Econometrics: A Modern Approach (2013, 5th ed., p. 122)

$Where$:

$\hat{\beta}_j = regression\ coefficient$

$SE(\hat{\beta}_j) = standard\ error\ of\ the\ estimated\ coefficient$

2. Test of Goodness of Fit

R2, also referred to as the coefficient of determination, is a value that indicates how well the model fits the data. It represents a statistical measure of the similarity between the regression line and the actual data in regression analysis.

$$R^2 = \frac{SSE}{SST} = 1 - \frac{SSR}{SST}$$

Source: Introductory Econometrics: A Modern Approach (2013, 5th ed., p. 38)

$Where$:

$SSE = explained\ sum\ of\ squares$

$SSR = residual\ sum\ of\ squares$

$SST = total\ sum\ of\ squares$

3. Test of Autocorrelation

The Durbin-Watson test is employed by the researchers, who compared the alternative hypothesis of autocorrelation with the null hypothesis that the residuals and the linear regression of the time series data are uncorrelated.

$$d = \frac{\sum_{t=2}^{T} = (e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}$$

Source: Introductory Econometrics: A Modern Approach (2020, 7th ed., p. 403)

To address potential first-order autocorrelation in the time-series data, the study employs the Prais–Winsten regression with AR(1) correction, which adjusts the estimated coefficients while retaining the first observation, thereby improving the efficiency and reliability of the results.

$$ut = pu_{t-1} + \varepsilon_t,\ |p| < 1$$

Source: Introductory Econometrics: A Modern Approach (2020, 7th ed., p. 402)

4. Test of Specific Error

The researchers tested the error of variables used through the Ramsey Regression Equation Specification Error Test (RESET) to assess whether significant variables have been omitted or the linear specification is insufficient in capturing accurate results.

$$F = \frac{(RSS_R - RSS_{UR}) / q}{RSS_{UR} / (n-k)}$$

Source: Basic Econometrics (2004, 4th ed., p. 262)

$Where$:

$SSRr = sum\ of\ squares\ restricted\ model$

$SSRur = sum\ of\ squares\ unrestricted\ model$

$q = number\ of\ restrictions$

$n = number\ of\ observations$

$k = number\ of\ regressors\ in\ unrestricted\ model$

5. Multicollinearity Test

To assess potential multicollinearity in the model, the researchers used the Variance Inflation Factor (VIF) as a diagnostic tool. This method helps researchers determine whether the independent variables exhibit a strong correlation that could distort the estimated coefficients.

$$VIF_j = \frac{1}{1 - R_j^2}$$

Source: Introductory Econometrics: A Modern Approach (2013, 5th ed., p. 98)

This study also used the measure of tolerance:

$$TOL_j = \frac{1}{VIF_j} = (1 - R_j^2)$$

Source: Basic Econometrics (2004, 4th ed., p. 353)

6. Parameter Structural Stability Test

Given the observations from the annual time-series data, the Chow Test will be applied to verify the structural stability of the regression coefficients.

Following the decline of the total fertility rate below the replacement level in 2017, the Chow Test will be applied to verify the structural stability of the regression coefficients based on annual time-series data.

$$F = \frac{(RSS_R - RSS_{UR}) / k}{RSS_{UR} / (n_1 + n_2 - 2k)}$$

Source: Basic Econometrics (2004, 4th ed., p. 276)

$Where$:

$RSS_R = restricted\ residual\ sum\ of\ squares$

$RSS_{UR} = unrestricted\ residual\ sum\ of\ squares$

$k = number\ of\ parameters\ estimated$

$n_1\ and\ n_2 = number\ of\ observations$

7. Normality Test

The Jarque-Bera test is used to assess whether the skewness and kurtosis of the regression residuals are consistent with a normal distribution.

$$JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right]$$

Source: Basic Econometrics (2004, 4th ed., p. 148)

$Where$:

$n = sample\ size$

$S = skewness\ coefficient$

$K = kurtosis\ coefficient$